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LUMBER YIELD FROM ENGELMANN SPRUCE IN ARIZONA

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[Picea engelmanni]

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ABSTRACT

Lumber yields were obtained from 428 logs, of which 12 were culls, bucked from 101 Engelmann spruce trees in Arizona. The 416 merchantable logs had a gross scale of 51,830 board feet, an average defect deduction of 4.2 percent, and produced 61,709 board feet of lumber for a net scale recovery ratio of 124 percent.

Recovery relationships are indicated in summaries of the lumber recovery information by log scaling diameter and tree diameter. Lumber recovery averaged 39 percent of the gross cubic volume of the logs for a lumber recovery factor of 6.96 board feet of lumber per cubic foot of log. The higher valued lumber grade volume decreases with increasing log and tree size.

About 95 percent of the merchantable volume in the sample trees was sawn as merchantable logs.

Keywords: Lumber recovery studies, yield (lumber), Engelmann spruce, *Picea engelmannii*.

INTRODUCTION

To help determine the applicability of grading systems to Engelmann spruce (*Picea engelmannii* Parry) in Arizona, a lumber study was conducted jointly in 1971 by the U. S. Department of Interior, Bureau of Indian Affairs Area Office in Arizona; the Fort Apache Timber Company, Whiteriver, Arizona; and the Grade and Quality of Western Softwoods Project of the Pacific Northwest Forest and Range Experiment Station. The study obtained information on relationships of lumber recovery to log and tree sizes that are useful to the managers and users of Engelmann spruce timber. This report summarizes the lumber recovery information obtained in the study according to log scaling diameter and tree diameter at breast height.

PROCEDURE

The lumber yield data are based on 101 trees selected from a timber stand in the White Mountain area of the Fort Apache Indian Reservation. Foresters working in the area considered the stand to be representative of the production unit. Within the stand, individual sample trees were selected on the basis of diameter at breast height (d. b. h.) and stem quality. The objective was to sample trees that were representative of the full range of available tree characteristics. The majority of the sample trees were on a north-facing slope where the stand contained some Douglas-fir and aspen. Some sample trees were in a creek bottom and were essentially open grown.

The normal felling, bucking, and sawing practices of the company were followed as nearly as possible. Production equipment in the sawmill included a band headsaw, a gang saw, edger, and trimmer. Individual log identity was maintained on each piece of lumber through the sawing and surfacing phases of the study. Study personnel accomplished this by using paint color coding, numbering with lumber keel, and photographic and voice-recorded tally records.

The sample trees were bucked into logs and trucked to the Fort Apache Timber Company mill at Whiteriver, Arizona. At the time of sawing, study logs were brought from a storage area to the sawmill log deck, barked, bucked for sawing, and scaled. Each log was sawn with the intent of recovering optimum value through manufacture of the mill's usual lumber items of 2 x 4 light framing, 2 x 6 structural joists and planks, and 1-inch boards.

Lumber recovery information was obtained for 428 logs, of which 12 logs were cull. The 416 merchantable logs had the following length distribution:

Log length (*Feet*)	Number	Percent
8	3	0.7
10	19	4.6
12	37	8.9
14	18	4.3
16	323	77.6
18	7	1.7
20	9	2.2

The target length was 16 feet. Scaling was by Scribner Decimal C log rule, U.S. Forest Service Scaling Handbook rules, 20-foot maximum scaling length. Logs were culled if less than 33-1/3 percent sound.

The lumber was graded and tallied in a surfaced dry condition under the supervision of the Western Wood Products Association, according to the 1970 Standard Grading Rules for Western Lumber. The grades were:

1-inch boards	No. 2 Common & Btr.
	No. 3 Common
	No. 4 Common
	No. 5 Common
2 x 4 light framing	Construction & Btr.
	Standard
	Utility
	Economy
2 x 6 structural joists and planks	No. 1 & Btr.
	No. 2
	No. 3
	Economy

LUMBER RECOVERY - LOGS

The log scale, lumber tally, and cubic volumes obtained from the study logs are summarized in table 1. The gross scale of the 416 merchantable logs was 51,830 board feet. Defect deductions averaged 4.2 percent for a total net scale of 49,650 board feet. Scale deductions do not appear to be related to log size in this sample.

The merchantable logs produced 61,709 board feet of lumber, which is a net

Table 1.—Log scale, lumber tally, and cubic volumes of sawn logs by log scaling diameter

Log scaling diameter (inches)	Number of logs	Log scale		Lumber tally		Cubic volume				
		Gross	Net	Volume	Recovery[1/]	Log	Lumber	Lumber recovery[2/]	Sawdust	Residue
		Board feet			*Percent*	*Cubic feet*		*Percent*	*Cubic feet*	
Merchantable logs:										
6	6	60	60	123	205	23.11	6.75	29	1.44	14.92
7	25	630	620	653	105	132.82	36.30	27	7.50	89.02
8	43	1,120	1,100	1,480	135	294.42	83.16	28	16.96	194.30
9	39	1,490	1,440	1,936	134	347.98	109.31	31	21.70	216.97
10	30	1,660	1,560	1,929	124	324.36	109.00	34	21.98	193.38
11	41	2,620	2,550	3,174	125	513.46	178.03	35	36.19	299.24
12	33	2,610	2,430	3,277	135	506.05	183.11	36	37.36	285.58
13	25	2,430	2,310	2,945	128	435.55	163.75	38	33.83	237.97
14	27	2,850	2,730	3,802	139	537.60	209.50	39	43.75	284.35
15	32	4,460	4,170	5,514	132	771.26	305.33	40	63.51	402.42
16	20	3,100	3,090	4,090	132	520.67	227.90	44	46.78	245.99
17	13	2,280	2,220	2,884	130	384.20	162.08	42	32.53	189.59
18	16	3,360	3,240	4,039	125	545.29	229.06	42	44.67	271.56
19	15	3,540	3,360	4,126	123	551.01	234.54	43	45.64	270.83
20	9	2,410	2,410	2,667	111	366.03	151.32	41	29.39	185.32
21	12	3,530	3,330	4,162	125	563.65	236.21	42	46.14	281.30
22	7	2,230	2,080	2,701	130	339.15	153.36	45	29.73	156.06
23	3	1,140	1,110	1,221	110	162.53	69.46	43	13.44	79.63
24	6	2,400	2,380	2,763	116	417.92	157.20	38	30.24	230.48
25	4	1,840	1,720	1,866	109	243.61	106.26	44	20.49	116.86
26	1	500	420	476	113	79.94	26.80	34	5.31	47.83
27	3	1,650	1,570	1,532	98	231.12	87.35	38	16.95	126.82
28	1	580	560	595	106	73.48	33.91	46	6.46	33.11
29	2	1,220	1,160	1,401	121	183.57	79.90	44	15.54	88.13
30	2	1,320	1,270	1,426	112	194.82	81.41	42	15.71	97.70
31	0	--	--	--	--	--	--	--	--	--
32	0	--	--	--	--	--	--	--	--	--
33	0	--	--	--	--	--	--	--	--	--
34	1	800	760	927	122	120.25	52.73	44	10.10	57.42
Total	416	51,830	49,650	61,709	124	8,863.85	3,473.73	39	693.34	4,696.78
Cull logs	12	950	0	972	--	168.83	54.68	32	10.90	103.25

[1/] Lumber tally volume as percentage of net scale volume.

[2/] Lumber cubic volume as percentage of log cubic volume.

scale recovery ratio (overrun) of 124.3 percent. The lumber tally volume is based on nominal shipping tally dimensions. Although there is an apparent trend for the net scale recovery ratio to decrease with an increase in log diameter, the relationship is not statistically significant.

The gross cubic log volume was computed by the following formula:

$$\text{Gross cubic log volume} = 0.001818L(D_s^2 + D_s D_1 + D_1^2)$$

where:

D_s is the log scaling diameter, small end;

D_1 is the log scaling diameter, large end; and

L is the log scaling length.

The lumber cubic volumes are based on the actual surfaced dry lumber dimensions. The sawdust volume was calculated by using an assumed average sawkerf of 7/32-inch and the computed surface area of the lumber in each log. The residue volume was obtained by subtracting the lumber and sawdust volume from the gross cubic log volume. Thus, the residue volume includes a small amount of sawdust associated with the production of slabs, edgings, and trim ends.[1/] Note that the gross cubic volume is based on scale lengths. Thus, an average trim allowance of 6 inches would increase the gross cubic volume by 3.3 percent, and there would be a corresponding increase in the volume of residue.

The cubic lumber recovery ratio is significantly related to log diameter (fig. 1). The cubic lumber recovery ratio increases from about 25 percent for 6-inch logs to 43 percent for 20- to 25-inch logs. The average ratio for this sample was 39.2 percent. The lumber recovery per cubic foot of log (lumber recovery factor) averaged 6.96 board feet per cubic foot. This ratio is also related to log size (fig. 2). It ranges from about 4.5 board feet for 6-inch logs to about 7.5 board feet for 22-inch logs.

The 12 cull logs that were sawn had a gross scale of 950 board feet and produced 972 board feet of lumber.

Log volume and lumber recovery values for the average study log in this and several other recent studies[2/] are as follows:

Species	Gross scale (*Board feet*)	Cubic volume (*Cubic feet*)	Net scale recovery ratio (*Percent*)	Lumber recovery factor	Basis (*Number of logs*)
Engelmann spruce:					
Whiteriver, Ariz.	124.6	21.31	124	6.96	416
Natal, B.C.	74.5	14.88	126	6.15	503
Moyie Springs, Idaho	123.8	21.96	135	7.13	990
East-side Douglas-fir	129.5	22.37	130	6.66	4,971
Western larch	126.4	20.76	127	6.66	2,810

[1/] A more detailed explanation of the computation procedure may be found in : John W. Henley and Jill M. Hoopes, An electronic computer program for calculating saw log lumber recovery and value, USDA Forest Service, 47 p., Pacific Northwest Forest and Range Experiment Station, Portland, Oregon, 1967.

[2/] Donald R. Gedney and John Henley. Utilization estimates for western softwoods--trees, logs, and residue. USDA Forest Service Research Note PNW-158, 8 p., Pacific Northwest Forest and Range Experiment Station, Portland, Oregon, 1971.

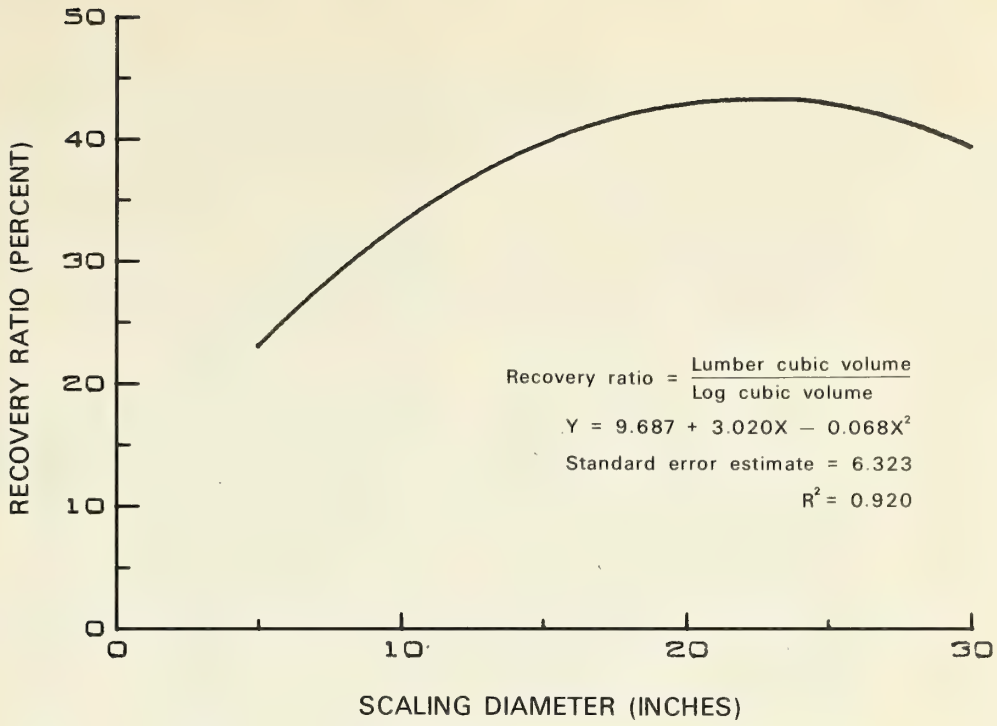

Figure 1.--Relationship of lumber cubic recovery ratio to scaling diameter - merchantable logs.

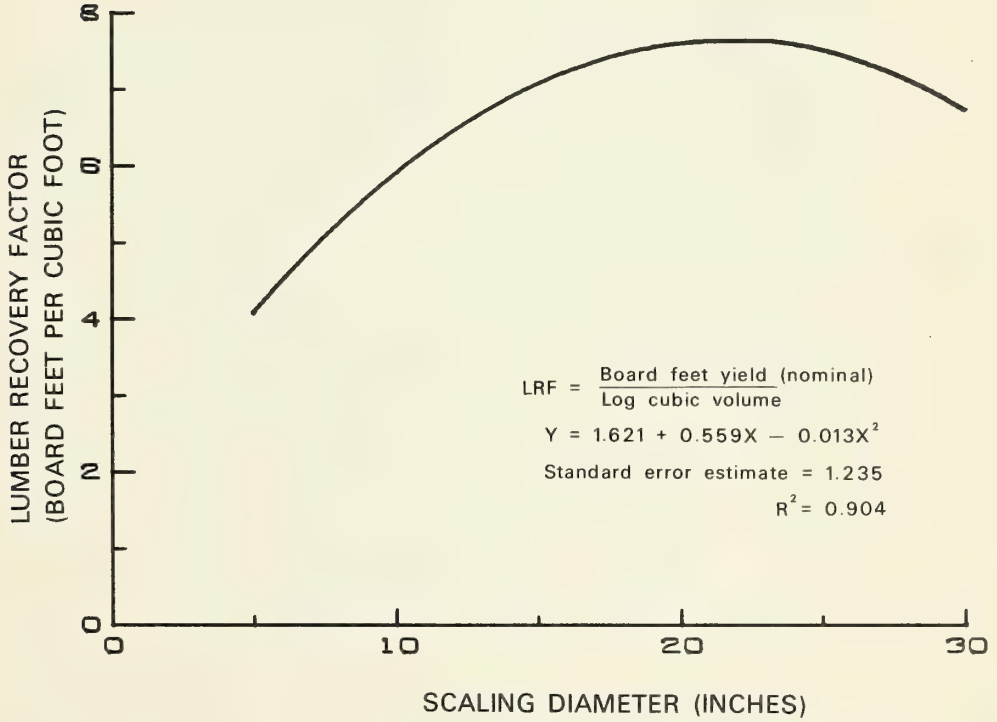

Figure 2.--Relationship of lumber recovery factor (LRF) to scaling diameter - merchantable logs.

The results of this study appear to fall in line with those obtained in other studies. The Natal, B.C., study logs were sawn in 1966. The principal items sawn were 2-inch dimension. The Moyie Springs, Idaho, study logs were sawn in 1962 into 1-inch boards.

A 1957 study of Engelmann spruce in southwestern Colorado[3/] obtained lower recovery values. In this study, the average log had a gross scale of 97.8 board feet and a net scale recovery ratio of 106 percent. One-inch boards were sawn in the study.

The surfaced dry lumber grade recovery percentages are shown by diameter in table 2. The higher value lumber grade volume tends to decrease with increasing log size (fig. 3). Conversely, the lower value lumber (Utility, No. 3 Common, and Economy) production increased with increasing log diameter.

3/ Lincoln A. Mueller and Roland L. Barger. Lumber grade recovery from Engelmann spruce in Colorado. USDA Forest Service Research Paper RM-1, 23 p., Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo., 1963.

Table 2.—Lumber grade yields of sawn logs by scaling diameter

Log scaling diameter (inches)	Number of logs	Total lumber tally	Lumber grade										
			No. 1	No. 2	No. 3	Construction	Standard	Utility	Economy	No. 2 Common	No. 3 Common	No. 4 Common	No. 5 Common
Merchantable logs:		*Board feet*	*Percent of total lumber tally*										
6	6	123	8.13	0	0	46.34	40.65	0	0	0	0	4.88	0
7	25	653	14.09	8.88	3.68	35.38	25.42	5.82	4.90	1.22	0	.61	0
8	43	1,480	20.00	18.92	10.14	26.49	11.22	5.81	2.97	.20	1.55	2.03	.68
9	39	1,936	26.45	27.27	7.85	13.53	8.94	4.86	7.90	.77	1.45	.98	0
10	30	1,929	25.71	29.55	7.36	11.82	9.38	7.31	3.99	.16	2.38	2.13	.21
11	41	3,174	22.69	17.20	6.30	20.98	17.83	7.09	4.44	.32	.69	2.08	.38
12	33	3,277	15.93	19.04	6.17	23.86	15.72	10.31	5.68	0	.82	1.95	.52
13	25	2,945	14.20	12.97	3.26	35.45	19.76	7.57	3.53	.51	1.05	1.50	.20
14	27	3,802	7.89	6.36	2.37	42.87	25.78	9.15	3.29	.18	1.13	.87	.11
15	32	5,514	7.91	9.21	2.47	34.44	29.51	7.16	6.55	.14	.98	1.47	.16
16	20	4,090	16.82	11.15	6.84	33.35	19.54	6.26	3.13	.20	1.12	1.10	.49
17	13	2,884	20.80	17.96	11.86	22.68	9.78	5.44	8.60	0	1.00	1.39	.49
18	16	4,039	38.03	24.81	10.50	12.38	5.00	2.30	4.78	.25	.47	1.19	.30
19	15	4,126	28.60	23.46	11.59	6.45	5.84	2.42	18.93	.07	.97	.87	.80
20	9	2,667	37.05	24.75	11.32	10.50	6.82	1.69	6.08	.41	.26	1.12	0
21	12	4,162	28.50	26.53	14.32	9.88	5.31	4.01	8.94	.31	.19	1.39	.62
22	7	2,701	29.25	23.92	14.22	11.18	2.00	3.52	14.11	.11	0	1.70	0
23	3	1,221	27.68	33.25	19.66	6.88	4.42	.66	5.08	0	.66	1.15	.57
24	6	2,763	20.05	26.42	24.10	6.12	3.47	2.68	15.89	0	.36	.51	.40
25	4	1,866	29.15	30.76	13.18	5.47	5.04	.38	13.77	0	.48	1.50	.27
26	1	476	27.31	20.59	9.66	26.05	9.87	0	5.25	0	0	0	1.26
27	3	1,532	20.37	35.90	14.10	3.52	4.05	1.24	17.49	.20	.85	1.96	.33
28	1	595	11.43	37.65	28.24	1.34	4.20	3.19	13.28	0	0	.67	0
29	2	1,401	9.42	26.27	29.12	2.07	6.57	5.71	18.27	0	.36	.93	1.28
30	2	1,426	17.95	31.56	22.44	2.95	5.40	4.84	12.76	0	0	2.10	0
31	0	--	--	--	--	--	--	--	--	--	--	--	--
32	0	--	--	--	--	--	--	--	--	--	--	--	--
33	0	--	--	--	--	--	--	--	--	--	--	--	--
34	1	927	5.18	29.13	25.46	.97	2.91	7.34	28.48	0	0	0	.54
Total	416	61,709	21.31	20.68	10.60	18.78	12.26	5.10	8.62	.19	.76	1.34	.36
Cull logs	12	972	5.76	8.44	22.63	10.91	10.80	14.30	25.21	0	.31	.51	1.13

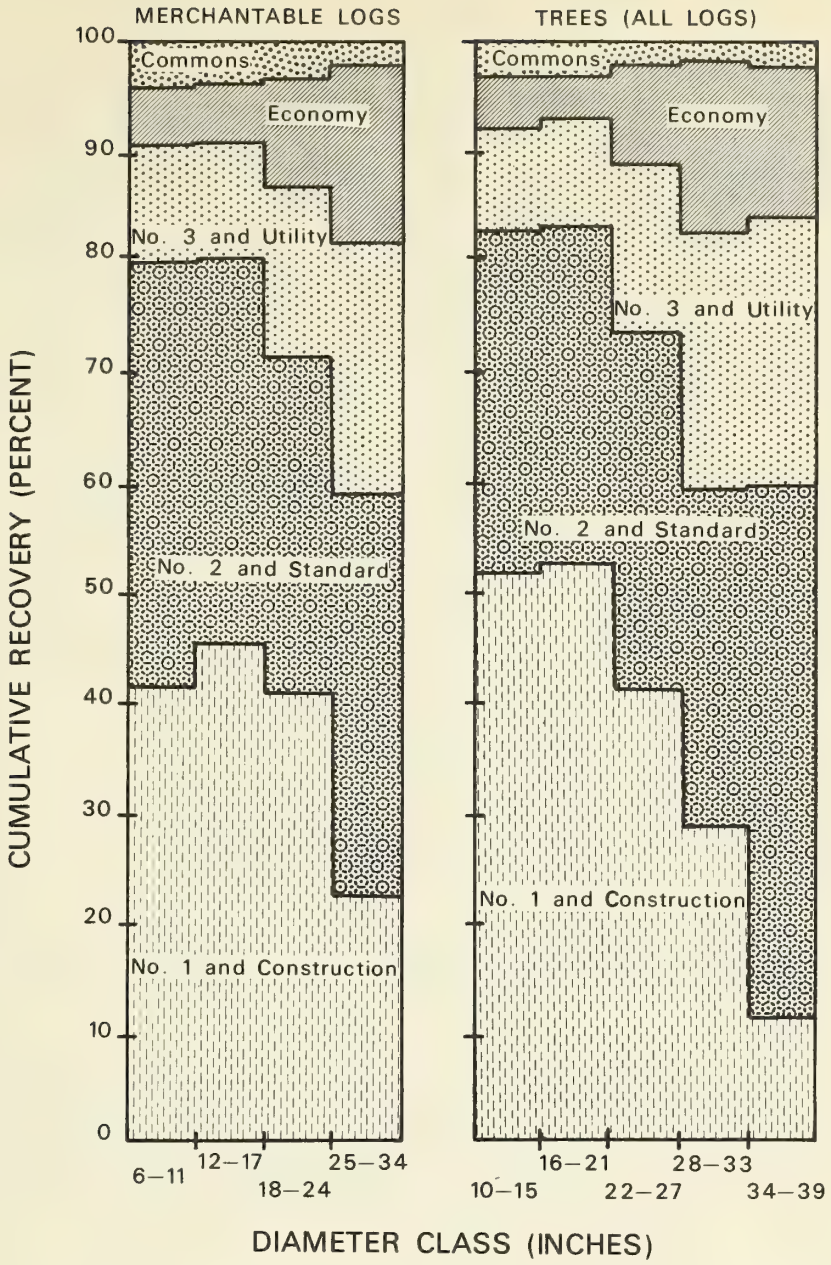

Figure 3.--Relative lumber grade recovery for 6-inch size classes of logs and trees.

LUMBER RECOVERY - TREES

Log scale, lumber tally, and cubic volumes obtained for the 101 study trees are summarized in table 3. These values were obtained by adding log values. The gross board-foot scale volumes and the cubic-foot tree volumes include the broken and other cull segments of the tree bole that were left in the woods. In the cases where the tree top broke or was cull, volumes are to an 8-inch merchantable top diameter. Thus, the total gross scale of 54,000 board feet represents the maximum volume that could have been removed from the woods, according to the bucking practices followed by the company.

The gross tree scale volume and cubic volume breaks down into the following categories:

	Gross scale volume	Cubic volume
	Percent	
Merchantable logs	96.0	95.4
Cull logs that were sawn	1.8	1.8
Cull logs not sawn	1.5	1.7
Breakage	.7	1.1

The volume in the tree tops above the merchantable top diameter is not included.

Thirty-eight percent of the available cubic-foot volume in the trees was manufactured into lumber. This amounts to an average recovery of 6.75 board feet per cubic foot of log volume.

The lumber grade recovery percents are summarized by trees in table 4. The relative amounts of the better quality lumber items tend to decrease as tree size increases (fig. 3).

The average defect (cull logs, breakage, and scale deductions) was 8 percent. The defect decreases with increasing tree size (fig. 4). The net scale recovery ratio (overrun) changes with tree size (fig. 5). The average ratio was 126 percent. The cubic recovery ratios are similar to those obtained for logs and are shown in figures 6 and 7.

Table 3.—Log scale, lumber tally, and cubic volumes of trees by tree diameter at breast height

Tree d.b.h. (inches)	Number of trees	Log scale		Lumber tally		Cubic volume				
		Gross	Net	Volume	Recovery[1]	Tree	Lumber	Lumber recovery[2]	Sawdust	Residue
		Board feet			Percent	Cubic feet		Percent	Cubic feet	
10	1	90	60	47	78	18.17	2.65	15	0.56	14.96
11	10	730	570	688	121	166.87	38.40	23	7.76	120.71
12	4	360	330	416	126	81.19	23.24	29	4.79	53.16
13	6	900	740	1,008	136	184.07	56.56	31	11.45	116.06
14	3	570	510	670	131	114.43	37.87	33	7.44	69.12
15	10	2,110	1,830	2,326	127	415.45	130.52	31	26.59	258.34
16	8	1,920	1,590	1,994	125	371.49	111.48	30	22.59	237.42
17	6	1,800	1,390	2,061	148	344.36	114.89	33	23.61	205.86
18	6	2,100	2,030	2,738	135	416.35	151.97	37	31.78	232.60
19	6	2,490	2,490	3,125	126	469.96	173.72	37	36.12	260.12
20	4	1,970	1,840	2,260	123	345.69	126.03	36	25.73	193.93
21	5	2,930	2,910	3,888	134	524.22	217.24	41	43.95	263.03
22	4	2,460	2,120	2,662	126	440.71	148.94	34	30.07	261.70
23	4	2,860	2,380	3,448	145	502.84	193.72	39	38.58	270.54
24	6	5,340	4,980	6,226	125	870.59	350.89	40	69.69	450.01
25	1	910	910	1,127	124	151.54	63.41	42	12.55	75.58
26	5	5,070	4,700	5,956	127	837.29	336.88	40	66.27	434.14
27	2	2,140	2,090	2,539	121	351.14	143.55	41	28.39	179.20
28	0	--	--	--	--	--	--	--	--	--
29	2	2,660	2,370	2,868	121	425.08	162.03	38	31.85	231.20
30	1	1,320	1,290	1,744	135	225.63	98.71	44	19.35	107.57
31	0	--	--	--	--	--	--	--	--	--
32	1	900	880	1,127	128	174.63	63.70	36	12.76	98.17
33	1	1,560	1,280	1,829	143	245.63	103.41	42	20.24	121.98
34	1	2,030	1,930	2,162	112	307.48	122.69	40	24.00	160.79
35	1	2,250	2,230	2,472	111	329.45	140.61	43	27.25	161.59
36	0	--	--	--	--	--	--	--	--	--
37	1	2,190	2,050	2,449	119	324.86	139.28	43	27.09	158.49
38	1	1,980	1,870	2,153	115	298.40	122.32	41	24.18	151.90
39	1	2,360	2,280	2,698	118	353.13	153.70	44	29.60	169.83
Total	101	54,000	49,650	62,681	126	9,290.65	3,528.41	38	704.24	5,058.00

[1] Lumber tally volume as percentage of net scale volume.

[2] Lumber cubic volume as percentage of log cubic volume.

Table 4.—Lumber grade yields of trees by diameter breast height (d.b.h.)

Tree d.b.h. (inches)	Number of trees	Total lumber tally	Lumber grade										
			No. 1	No. 2	No. 3	Construction	Standard	Utility	Economy	No. 2 Common	No. 3 Common	No. 4 Common	No. 5 Common
		Board feet	Percent of total lumber tally										
10	1	47	34.04	21.28	0	23.40	0	0	10.64	10.64	0	0	0
11	10	688	20.06	18.02	6.10	29.65	14.10	8.28	1.74	.58	.87	.58	0
12	4	416	19.23	11.06	0	27.88	9.86	13.70	13.94	.72	1.68	1.92	0
13	6	1,008	25.20	18.85	7.54	22.12	13.69	6.55	2.58	0	1.79	1.69	0
14	3	670	32.84	25.07	3.58	16.57	8.51	4.78	7.16	0	1.04	.45	0
15	10	2,326	24.76	16.17	4.13	30.91	12.94	3.48	4.00	.26	1.76	.99	.60
16	8	1,994	23.87	17.65	2.71	32.85	12.94	4.71	2.66	.25	.40	1.96	0
17	6	2,061	15.14	15.33	6.60	23.58	17.61	14.51	3.74	.15	1.12	1.99	.24
18	6	2,738	12.05	10.71	3.29	34.59	22.13	7.60	6.10	.58	1.97	1.39	.29
19	6	3,125	11.90	12.74	4.22	40.13	20.93	3.78	2.46	.58	.90	2.27	.10
20	4	2,260	17.96	15.22	5.58	35.40	12.65	6.73	3.50	.44	.31	1.86	.35
21	5	3,888	25.46	11.78	5.14	35.60	14.17	2.34	3.29	.26	.21	1.34	.41
22	4	2,662	19.31	17.51	5.48	22.13	18.75	7.48	7.06	0	.75	1.01	.53
23	4	3,448	28.89	12.82	7.83	21.29	10.88	6.29	10.01	.09	.55	1.13	.23
24	6	6,226	26.89	20.04	9.09	15.23	14.07	4.21	7.87	.45	.47	1.12	.56
25	1	1,127	26.09	22.36	10.65	15.08	10.38	3.64	9.49	0	.35	.44	1.51
26	5	5,956	29.15	23.91	10.61	11.38	10.80	4.15	7.71	.05	.89	1.02	.34
27	2	2,539	18.35	25.60	13.71	11.11	10.00	5.67	12.84	0	.59	1.73	.39
28	0	--	--	--	--	--	--	--	--	--	--	--	--
29	2	2,868	10.67	18.69	19.25	10.60	11.54	4.39	22.87	.10	.66	1.08	.14
30	1	1,744	34.29	16.86	12.04	16.11	8.89	2.06	7.86	0	.46	1.43	0
31	0	--	--	--	--	--	--	--	--	--	--	--	--
32	1	1,127	4.44	16.68	23.60	3.73	15.17	11.45	21.56	0	1.77	.98	.62
33	1	1,829	17.93	26.46	19.79	14.76	7.38	3.55	8.75	0	.27	.77	.33
34	1	2,162	31.82	24.33	12.12	8.23	7.59	3.56	9.67	0	.74	1.94	0
35	1	2,472	29.85	33.01	11.49	4.13	5.62	4.13	9.47	0	.28	1.82	.20
36	0	--	--	--	--	--	--	--	--	--	--	--	--
37	1	2,449	8.25	29.89	26.62	3.39	5.92	5.72	18.09	.12	.20	1.63	.16
38	1	2,153	8.45	33.53	22.29	4.64	8.45	4.60	13.84	.14	1.11	1.30	1.63
39	1	2,698	9.86	37.36	23.65	.89	4.74	5.37	16.57	0	.82	.56	.19
Total	101	62,681	21.07	20.49	10.79	18.66	12.23	5.24	8.88	.20	.75	1.33	.36

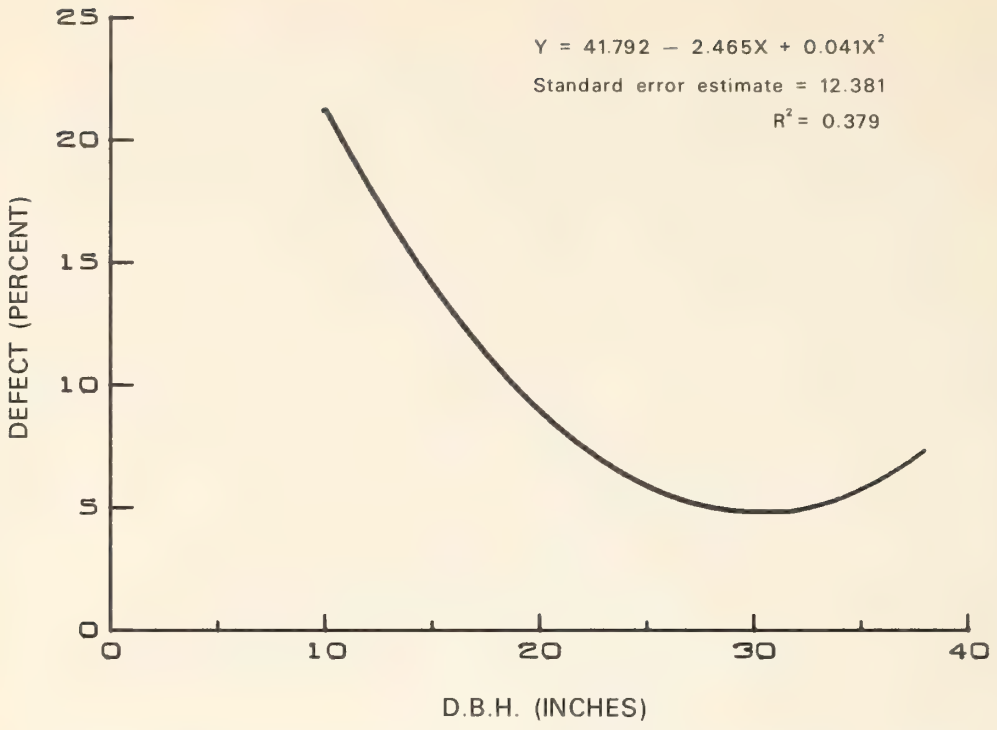

Figure 4.--Relationship of scale defect to tree diameter at breast height (d.b.h.).

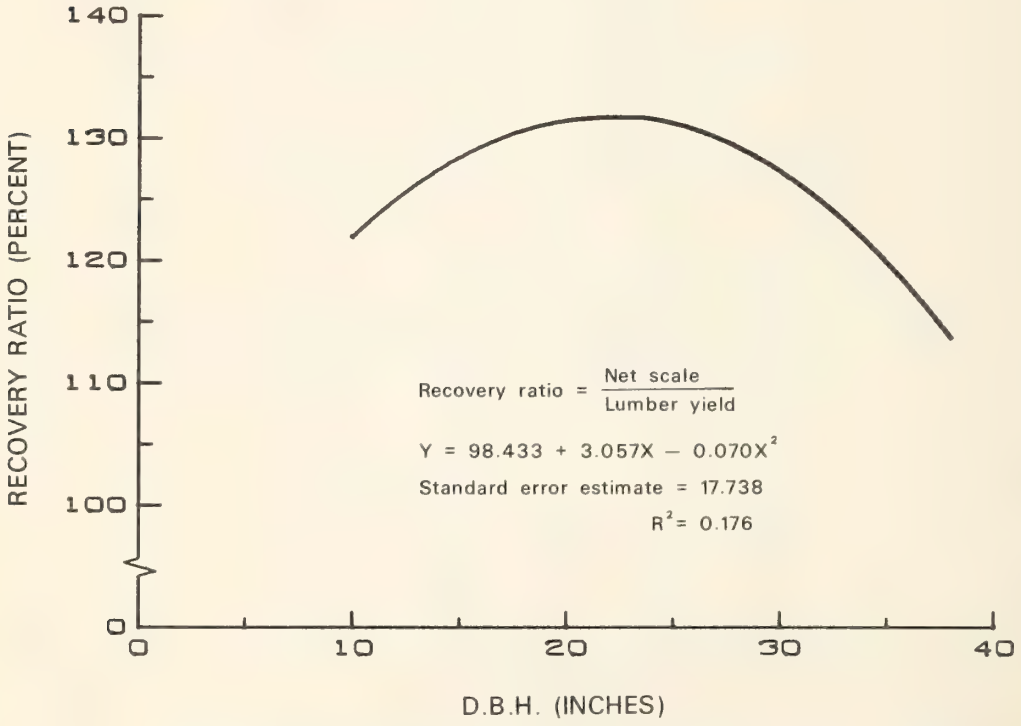

Figure 5.--Relationship of net scale recovery ratio to tree diameter at breast height (d.b.h.).

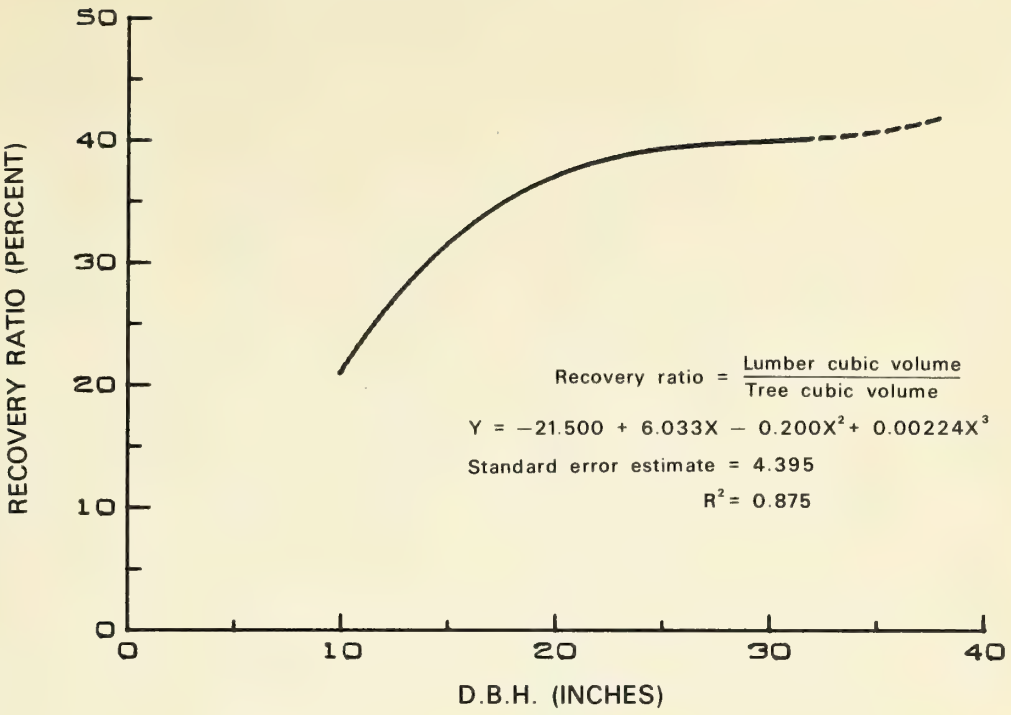

Figure 6.--Relationship of cubic recovery ratio to tree diameter at breast height (d.b.h.).

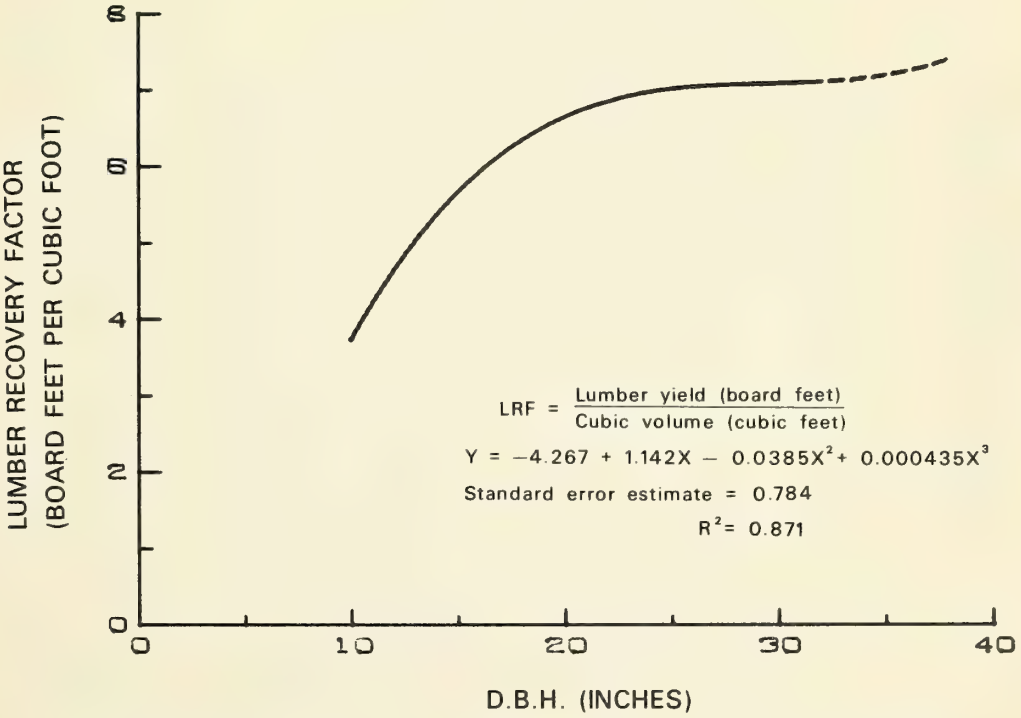

Figure 7.--Relationship of lumber recovery factor (LRF) to tree diameter at breast height (d.b.h.).

Henley, John W., and Marlin E. Plank
1973. Lumber yield from Engelmann spruce in Arizona. USDA For. Serv. Res. Pap. PNW-170, 11 p., illus. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Presents lumber yield relationships by log and tree diameters for Engelmann spruce trees selected and sawn in Arizona.

Keywords: Lumber recovery studies, yield (lumber), Engelmann spruce, *Picea engelmannii*.

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